

3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015)

## Possiblistic-Fuzzy C-Means Clustering Approach for the Segmentation of Satellite Images in HSL Color Space

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### Abstract

Image segmentation is the process of splitting an image into number of sub images or extracting the necessary portions from the image. The segmentation of satellite image is a challenging but important task for the subsequent processes in the image analysis. In this paper, Possiblistic-fuzzy c-means based segmentation of satellite image is proposed. Possiblistic-fuzzy c-means (PFCM) clustering is a blended version of fuzzy c-means (FCM) clustering and possiblistic c-means (PCM) clustering. The PFCM clustering stay away from various limitations of both PCM and FCM. PFCM resolves the noise sensitivity problem of FCM. Moreover PFCM gives answer to the coincident clusters problem in PCM clustering and the row sum constraint problem in FPCM clustering. In the proposed approach, before segmentation, the satellite images are transformed from RGB color space into HSL space. The polar coordinate, user oriented HSL color space approximate the human vision and represents the colors in more perceptually and intuitive manner than the RGB representation. The segmentation of satellite images in RGB and HSL color space is compared and the experimental result shows that competence of the proposed approach.

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Peer-review under responsibility of organizing committee of the 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015)

**Keywords**—PFCM; color space; HSL; RGB, segmentation; clustering

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## 1. Introduction

Segmentation is an initial but important process in the satellite image processing to collect huge amount of information from the satellite images. In this process, the satellite image is partitioned into number of sub images or clusters according to any one characteristics of the image such as texture, intensity or color. It is necessary to consider an efficient and effective approach for the segmentation of the satellite image to gather valuable information from the satellite images. There is no unique method for the satellite image segmentation. Many approaches are proposed but everyone has its own advantages and disadvantages. In this process, the image pixels are grouped according to any one characteristics of the image [5][16]. The images received from satellite are usually in RGB color space. This color space is not preferred for image segmentation because this space is not perceptually uniform and all components should be quantized with the same precision [19][20][21]. So the image is converted from RGB space to other color space by either linear or nonlinear transformations. In this paper, an efficient segmentation of satellite images in HSL color space using possibilistic-fuzzy c-means is proposed. The remainder of the paper is organized as follows. The section 2 gives the information about color space. The section 3 covers PFCM clustering. The proposed for satellite image segmentation is explained in the section 4. The section 5 describes the experiments on the proposed method and finally the section 6 concludes the paper.

## 2. An Overview of Color Space for Segmentation

Color space is the mathematical representation of the colors which are arranged in three dimensional Cartesian coordinates. Color space gives the useful information such as how the colors are represented and specifies the components of color space accurately [9]. The numbers of color models are available for different applications such as color printing, TV broadcasting, and image analysis [13]. The color space may be device dependent or device independent. In the device dependent color space, the color produced on the display depends on the device or equipment used for display and the set of parameters which defines color space. This category includes RGB, CMY, CMYK, YIQ, YUV, and YCbCr. In the case of device independent color space, the color produce depends only on a set of parameters irrespective of equipment or manufacturer. This category includes CIE XYZ, CIE  $L^*U^*V^*$ , and CIE  $L^*a^*b^*$ [10].

### 2.1 RGB Color Space

According to [2], the RGB color space is represented by three dimensional Cartesian coordinate system by three components as red, green and blue. In this additive color space, other colors are produced by adding the primary colors red, green and blue. The combination of all three primary colors produces white color and the absence of all primary color makes black. The RGB color model is represented by a unit cube and the axes are labelled as R, G and B. The origin (0, 0, 0) is considered black and the diagonally opposite corner (1,1,1) is considered as pure white. This color space is widely used in television and computer monitors. Any other color space can be obtained from a linear or non-linear transformation from RGB. In this device dependent color space, chrominance and luminance component are mixed that is why RGB color space is not chosen for color analysis and color based segmentation algorithm.

### 2.2 HSL Color Space

This cylindrical coordinate color space represents the colors in more perceptual and intuitive manner than the RGB (Cartesian) representation. In this color space, colors are represented by three different components as hue, saturation and lightness. Hue denotes the base color either in degrees or numbers as shown in table. The

degrees or numbers in between reflect different shades. The second component saturation can be described as the ratio of colorfulness to lightness (brightness). Saturation is always expressed in terms of percentage. The saturation 100% means that color is fully saturated. The third component lightness can be defined as the brightness relative to the brightness of similarly illuminated white. Lightness is also expressed in terms of percentage i.e., 100% of lightness is white and 0% is black.

Table 1. Color representation and its hue value

Hue (degree)	Hue (value)	Color
0 or 360	0 or 6	red
60	1	yellow
120	2	green
180	3	cyan
240	4	blue
300	5	magenta

The transformation of an image in RGB color space to HSL color space is given as follows [11]

$$H = \arccos \frac{\frac{1}{2}(2R-G-B)}{\sqrt{(R-G)^2 - (R-B)(G-B)}} \quad (1)$$

$$L = \frac{\max(R,G,B) + \min(R,G,B)}{2} \quad (2)$$

$$S = \frac{\max(R,G,B) - \min(R,G,B)}{\max(R,G,B) + \min(R,G,B)} \text{ for } L < 0.5 \quad (3)$$

$$S = \frac{\max(R,G,B) - \min(R,G,B)}{2 - \max(R,G,B) - \min(R,G,B)} \text{ for } L \geq 0.5 \quad (4)$$

### 3. PFCM for Segmentation

In 1967, McQueen proposed a clustering algorithm called k-means clustering which is a crisp algorithm. In this algorithm, each data point is strictly belongs to only one cluster. Even though this algorithm is fast, especially in larger data, it is very difficult to determine to which cluster a data point belongs to exactly. The fuzzified version of the k-means clustering, fuzzy c-means (FCM), is proposed by Joe Dunn (1973) and improved by Jim Bezdek (1981). In this clustering, one data point belongs to more than one cluster based on its membership value. The sum of membership of each data point to all clusters is equal to one. In addition, this clustering algorithm is not desirable for the clustering of noisy data due to its noise friendly character. Krishnapuram and Keller (1993) proposed a method to overcome the limitations of the FCM clustering method.

In this possibilistic clustering means (PCM), the membership value of each data point can be interpreted as degree of compatibility (possibility). Heiko et. al. (2001) indicated that if all the cluster centers are identical, then only the objective function of PCM is minimized. Timm and Kruse (2002) added a term to PCM's objective function to inverse distance functions between cluster centers. Jiang She Zhang et. al. (2004) improved PCM algorithm by integrating a fuzzy approach into its objective function. Possibilistic-fuzzy c-means (PFCM) clustering is a mixture of fuzzy c-means (FCM) clustering and possibilistic c-means (PCM) clustering. The PFCM clustering avoids various shortcomings of both FCM and PCM. The main disadvantage of FCM is noise sensitivity. This means that FCM clustering algorithm considers noise pixels as image pixels. PFCM resolves this noise sensitivity problem of FCM. Moreover PFCM gives answer to the coincident clusters problem in PCM clustering and the row sum constraint problem in FPCM clustering. Pal et.al proposed a method, called PFCM, for clustering object into number of class satisfying both the constraints of FCM and PCM [1]. The objective of this clustering algorithm is minimizing its objective function as given in (5)

$$PF_m(T, V, U; X, \gamma) = \sum_{i=1}^n \sum_{k=1}^c (a\mu_{ik}^m + bt_{ik}^\eta) d_{ki}^2 + \sum_{i=1}^c \gamma_i \sum_{k=1}^n (1 - t_{ki})^\eta \quad (5)$$

Where  $m, \eta > 1$  and  $a, b, \gamma > 0$ . All are user defined constants. The following conditions are necessary to for the objective function to reach the final optimum (minimum) value.

$$V_i = \frac{\sum_{k=1}^n (a\mu_{ik}^m + bt_{ik}^\eta) x_k}{\sum_{k=1}^n (a\mu_{ik}^m + bt_{ik}^\eta)} \quad (6)$$

$$t_{ik} = \left( \frac{1}{1 + \left( \frac{d_{ik}^2}{\gamma_i} \right)^{1/(m-1)}} \right) \quad (7)$$

$$\mu_{ik} = \left( \frac{1}{\sum_{j=1}^c \left( \frac{d_{ik}}{d_{jk}} \right)^{2/m-1}} \right) \quad (8)$$

#### 4. Proposed Approach for the Segmentation of Satellite Images

Figure 1 shows the proposed approach for the segmentation of satellite images in using possibilistic fuzzy c means clustering algorithm. To test the efficiency of the proposed approach, a data base of 25 images was created. All the images were collected from global land cover facility gallery ([www.landcover.org](http://www.landcover.org)) which has a huge collection of free satellite images. Initially the input satellite images are sharpened for the purpose of sharpening the edges and minute the important details in the image. Then the sharpened image is transformed into HSL color space. In this color space, an image is represented as three different components as hue, saturation and lightness. The transformed image is then segmented by using possibilistic fuzzy c means clustering algorithm.

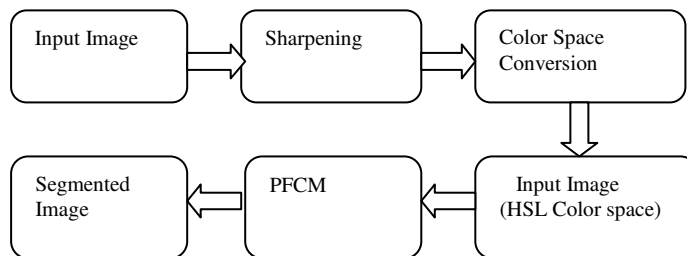


Fig. 1. The proposed approach for satellite image segmentation

The algorithm for the segmentation of satellite images using PFCM is explained as follows.

Step 1: The satellite image to be segmented is acquired from the database.

Step 2: The input image is sharpened using sharpening algorithm I. In this process, low and high clip percentage is selected as 0.005 and 0.2 respectively.

Step 3: The sharpened image is transformed into HSL color space.

Step 4: The Satellite image in HSL color space is segmented using PFCM clustering algorithm.

Step 5: The output is the segmented image

## 5. Experimental Result and Discussion

Figure 2 shows that input image in RGB color space and its sharpened version. This landsat image is obtained from global land cover facility gallery. The original size of this image is 185\*185 km with pixel resolution of 30m and spectral range of 0.450 to 2.35  $\mu\text{m}$ . However it was resized to 155\*155 pixels to reduce the computational cost. Figure 3 shows the histogram of three different components red, green and blue in the RGB image before and after sharpening of the image respectively. From the histogram, we can easily understand the impact of sharpening in the image segmentation process.

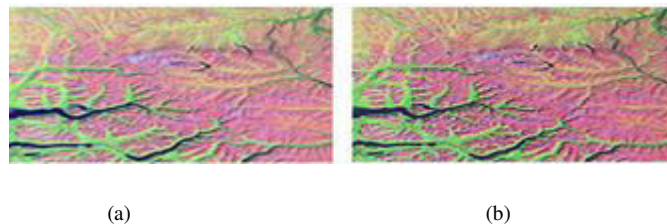


Fig. 2. Input Image (a) in RGB color space (b) Sharpened Image

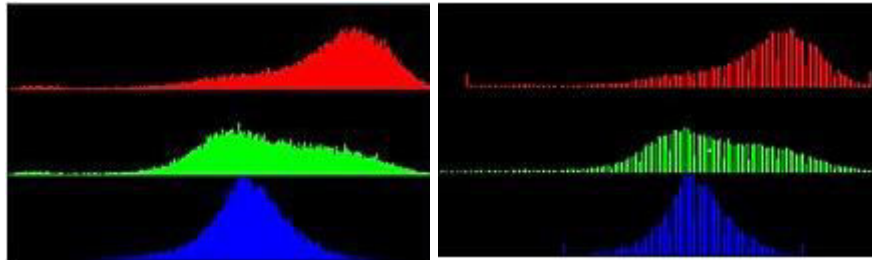


Fig. 3. Histogram of input Image in RGB color space before and after sharpening

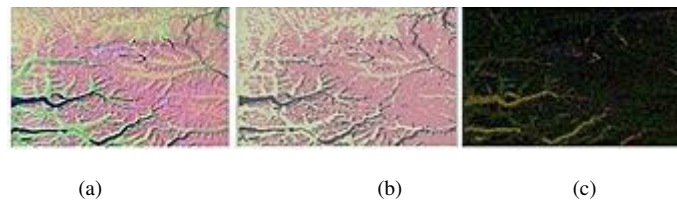


Fig. 4. The segmentation result of sharpened input image in RGB color space (a) input image in RGB color space (b) segmented image (c) error image.

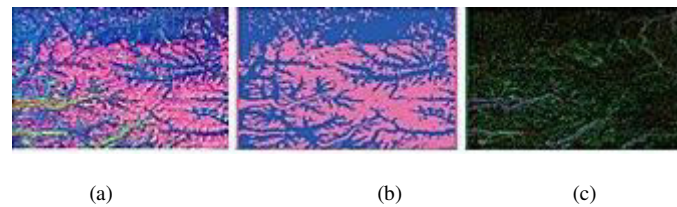


Fig. 5. The segmentation result of sharpened input image in HSL color space (a) input image in HSL color space (b) segmented image (c) error image.

Table 2. Comparison of segmentation results in RGB and HSV color space.

Parameter	Image 4(a) & 4(b)	Image 5(a) & 5(b)
No. of clusters	3	3
No. of iterations	15	7
Execution time	0.089402	0.060035
Mean Square Error	1.1300e+003	1.3627e+003
Peak Signal to Noise Ratio	17.5999	16.7869
Normalized Cross-Correlation	1.0243	1.0035
Average Difference	-6.6283	-5.2721
Structural Content	0.9191	0.9170
Maximum Difference	124	131
Normalized Absolute Error	0.1420	0.2335
RMS Error	21.62	23.60

## 6. Conclusion

In this paper, a new method for the segmentation of the satellite images based on the possibilistic-fuzzy c-means clustering is proposed. The PFCM clustering avoids various shortcomings of both FCM and PCM. PFCM resolves the noise sensitivity problem of FCM. Moreover PFCM gives answer to the coincident clusters problem in PCM clustering and the row sum constraint problem in FPCM clustering. Even though number of images are tested using the proposed method, the result of only one image is illustrated and explained in this article. In this color based segmentation, satellite images are segmented in both RGB and HSL color space. The result of the segmentation process in the RGB and HSL color space is compared using a group of image quality measures to test the efficiency of the proposed approach. From the discussion and result obtained we can easily conclude the paper that HSV based segmentation using PFCM is more efficient for satellite images especially in terms of computational cost.

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